

Weight Deviation and Health in a College Group

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THE need for a reliable and practical method of "screening out" college students whose anthropometric measurements deviate radically from the average of the bodily measurements of the majority of students of comparable age and development is urgent.* Extreme deviations in individual measurements may be indications of pathological or structural deficiencies which require thorough medical observation and therapeutics. The relation between height and weight has long been used as a "screen" for the detection of "underweight," "overweight," or "malnourished" cases. The value of this relationship has been questioned by investigators who have produced convincing evidence that there are other combinations of bodily traits which correlate more highly with physicians' estimates of nutritional status than that of height and weight.

A study of combinations of anthropometric traits which do have greater relationship with status of health as judged by competent physicians should facilitate the formulation of a new screening method which would be more valid and practical in its application to the examination of large groups of individuals. Such a screening device would in no sense replace the medical examination. It would merely select students who might profit by further and more thorough attention of medical experts. A predictive index and formula for "screening out" these students has been developed, and will be explained in Part I of this study.

Knowledge of the relationship of bodily, skeletal, or constitutional types to certain medical data, such as morbidity, frequency and length of periods of illness, occurrence of specific physical defects, etc., would facilitate the prediction and expectance of these factors for various types of individuals. It is hoped that this study will throw some light on this relationship. The public, at least, has considered that deviation from weight standards is indicative of poor health, especially malnutrition. Medical and other scientifically trained persons in health work have qualified this consideration. It can be said that most physicians today will look upon a case of extreme overweight or underweight as

suspicious of malfunction, or pathology. The wide-spread belief that underweight and overweight individuals do have "something wrong" with them is a major consideration in Part II of this dissertation. Specifically, if a person is fifteen per cent or more underweight, or twenty per cent or more overweight, do his medical examination and health records for a year show any cause or effect relationship? Is an underweight individual prone to certain diseases, and does he possess a preponderance of certain types of defects? Do overweight individuals have defects, illnesses, etc., which are peculiar to them? These questions will be answered to some degree in this study by comparing the health records of male members of the entire freshman class of 1938 with those records of men within the class who deviate excessively from certain standards for weight.

REVIEW OF LITERATURE

There is not space in this abstract to include an adequate survey of the literature in the field of anthropometric measurements in relation to the determination of weight and health status. It must suffice to

SUMMARY OF VARIOUS CORRELATIONS OF ANTHROPOMETRIC MEASUREMENTS FOUND IN THE LITERATURE WHICH ARE COMPARABLE TO THE CORRELATIONS OF MEASUREMENTS IN THE PRESENT STUDY

Bibliography Numbers	Source	Age Group (Males)	Number of Cases	* r_{12} Ht-Wt	r_{12} Ht-CGE	r_{12} Wt-CGE	$r_{12.3}$ Ht-Wt-CGE	$r_{12.3}$ Ht-CGE-WT	$r_{12.3}$ WT-CGE-Ht
No. 18	Selective Service Men	21-30	860,000	.4810	.2304	.6907	.4574	.1606	.6797
No. 2	Schuster	18	129	.500					
No. 2	Baldwin	17	60	.680	.556	.872			
No. 2	Mumford	18	25	.784	.373	.780			
No. 2	Young								
No. 2	U.S. Public H.S.	15-19	322	.711	.562	.846			
No. 2	Univ. of Minnesota	18	407	.484	.255	.726			
No. 2	U.S. Army Officers	20-24	483	.520	.243	.681			
No. 2	C.M.T.C.	18	28,727	.524	.295	.711			
No. 18	Love	21-24	2,360	.554	.331	.751			
No. 7	C. C. N. Y.	18	669	.523					
No. 7	U. of Calif.	18	508	.508					
No. 7	U. of Cinc.	18	718	.476					
No. 7	Cornell U.	18	833	.557					
No. 7	U. of Minn.	18	903	.499					
No. 7	Princeton U.	18	874	.500					
No. 7	Stanford U.	18	689	.525					
No. 7	U. of Texas	18	724	.437					
No. 7	U. of Wis.	18	591	.499					
No. 7	Yale Univ.	18	659	.493					

Ht = Height; Wt = Weight; CGE = Chest Girth Expanded; r_{12} = zero order correlation; $r_{12.3}$ = first order partial correlation.

refer to a few investigators.* Franzen,¹⁰ Diehl,⁷ Schmidt,²⁹ Quimby,¹⁵ and Boillin³ have been recent contributors to the knowledge of techniques for weight prediction. Excellent studies of the relation of constitutional types to disease have been made by Pearl and Ciocco,²³ Draper,⁸ Gould,¹⁵ Love,¹⁸ Love and Reed,¹⁹ and Dublin.⁹

A review of the literature shows an agreement between the authors in that there is a definite relationship between body build and certain types of diseases. It is rather surprising to find the agreement which is quite obvious in their assignment of certain diseases to distinct constitutional or skeletal types.

PART I

STUDY OF THE INTERRELATIONSHIP OF CERTAIN ANTHROPOMETRIC MEASUREMENTS AND THE DEVELOPMENT OF A PREDICTIVE FORMULA FOR WEIGHT FOR EIGHTEEN YEAR OLD COLLEGE MEN

The following anthropometric measurements were taken of the men entering the University of Michigan in the fall of 1934: height, weight, chest girth expanded and contracted, biceps contracted and extended, chest depth (normal inspiration; normal expiration) and hip width. Further references to them will be made using the following abbreviations: Height—Ht; Weight—Wt; Chest Girth Expanded—CGE; Chest Girth Contracted—CGC; Biceps Contracted—BiC; Biceps Extended—BiE; Chest Depth, Normal Inspiration—CDI; Chest Depth, Normal Expiration—CDE; and Hip Width—Hips. These measurements were taken using the usual anthropometric technique. Exact description of the latter may be found in the original dissertation.

In order to make the interpretation and calculations of the data

ZERO ORDER CORRELATIONS—NINE ANTHROPOMETRIC TRAITS

	Hip Width	Chest Depth Expired	Chest Depth Inspired	Biceps Ex- panded	Biceps Con- tracted	Chest Girth Con- tracted	Chest Girth Ex- panded	Weight
Height	.4869	.1968	.1856	.0487	.0908	.1731	.2299	.5212
Weight	.7450	.6423	.5915	.7535	.7603	.7609	.7776	
Chest Girth Expanded	.5059	.5455	.5456	.7147	.7135	.8975		
Chest Girth Contracted	.5161	.5138	.5535	.7009	.7087			
Biceps Contracted	.4887	.5182	.5114	.8859				
Biceps Extended	.4504	.5754	.5240					
Chest Depth Inspired	.4576	.8431						
Chest Depth Expired	.4499							

* Indices after author's names refer to the Bibliography at the end of this article.

manageable by one person, 459 cases from the eighteen year old group, with the nine measurements completed, were chosen for this study. The number of cases for the sixteen, seventeen, nineteen, and twenty year old age groups was too small to make any significant conclusions from their interpretation, and made impossible the development of a valid and reliable predictive formula for weight for any of the age groups except the eighteen year olds.

Zero order correlations were first determined for each of the above anthropometric traits with each of the others (table preceding page).

First order partial correlations of weight with the various other measurements were then made.

FIRST ORDER PARTIAL CORRELATIONS OF WEIGHT WITH EACH OF THE REMAINING TRAITS

Wt-Ht.	CGE	.5596	Wt-CDE.	Ht	.6450
	CGC	.6095		CGC	.4509
	BiC	.6990		CGE	.4139
	BiE	.7379		BiC	.4469
	CDI	.5192		BiE	.4912
	CDE	.5253		CDI	.3152
	Hips	.2717		Hips	.5155
Wt-CGE.	Ht	.7921	Wt-Hips.	Ht	.6996
	CGC	.3309		CGC	.6348
	BiC	.5165		CGE	.6492
	BiE	.5200		BiC	.6597
	CDI	.6732		BiE	.6919
	CDE	.6650		CDI	.6622
	Hips	.6966		CDE	.6668
Wt-CGC.	Ht	.7980	Wt-BiE.	Ht	.8389
	CGE	.2878		CGC	.4830
	BiC	.4846		CGE	.4664
	BiE	.4965		BiE	.3043
	CDI	.6456		CDI	.6607
	CDE	.6546		CDE	.6521
	Hips	.6588		Hips	.6810
Wt-BiE.	Ht	.8542	Wt-CDI.	Ht	.5900
	CGC	.4757		CGC	.3151
	CGE	.4495		CGE	.3173
	BiC	.2655		BiC	.3631
	CDI	.6460		BiE	.3518
	CDE	.6646		CDE	.0561
	Hips	.7019		Hips	.4225

THE PREDICTIVE EQUATION FOR WEIGHT OF EIGHTEEN YEAR OLD COLLEGE MEN

From an analysis of the zero and first order correlations, the best combination of anthropometric traits which can be used to predict weight for this group would be chest girth, girth of biceps, and the width of hips. Since the girth of chest expanded and the girth of the biceps contracted seem to have greater influence on the determination of weight than girth of chest contracted and girth of biceps extended,

the use of CGE, BiC, and Hips should give us our best predictive equation. The regression equation for predicting weight from these three measures is suggested by Holzinger¹⁶ (p. 302).

$$\bar{X}_1 = r_{12.34} \frac{\sigma_{1.34}}{\sigma_{2.34}} X_2 + r_{13.24} \frac{\sigma_{1.24}}{\sigma_{3.24}} X_3 + r_{14.23} X_4 + C$$

Substituting the calculations from our data, we finally have

$$\bar{X}_1 = 1.2032 \text{ CGE} + 1.168 \text{ (BiC)} + 2.6535 \text{ Hip Width} + (-19.006)$$

The Predicted Value of Wt in pounds = 1.203 (CGE in inches) + 1.168 (BiC in inches) + 2.6535 (Hip Width in centimeters) + (-19.006).

DETERMINATION OF WEIGHT BY USE OF THE PREDICTIVE FORMULA (Sample Case)

Eighteen Year Old College Male:

Chest Girth Expanded, in inches = 34.7

Biceps Girth Contracted, in inches = 29.2

Hip Width, in centimeters = 30.6

Applying the predictive formula we have

$$\text{Predicted Weight} = 1.203 \times 34.7 + 1.168 \times 29.2 + 2.654 \times 30.6 + (-19.006)$$

$$\text{Predicted Weight} = 41.744 + 34.106 + 81.212 - 19.006$$

$$\text{Predicted Weight} = 138.056 \text{ pounds.}$$

SELECTION OF UNDERWEIGHT AND OVERWEIGHT CASES BY THE USE OF THE PREDICTIVE FORMULA AND BY THE STANDARD TABLE

In the 459 cases of the eighteen year old men considered in this particular section of the report, 23 men were underweight at least 15 per cent in relation to their "standard" * weight, while 5 were 15 per cent or more underweight in relation to their weight as predicted with the devised formula. This would indicate that when a combination of chest girth expanded, biceps girth contracted, and hip width are used for prediction, 23 cases of the total of 28 cases of underweight men in the entire group would *not* be considered underweight. In the total group, 28 cases are at least 15 per cent underweight using the two standards for prediction, i.e., height alone, and the combination of the three anthropometric measurements. Two cases were selected as underweight by the battery of measurements in the predictive formula which were not 15 per cent or more underweight according to the standard tables; 16 cases were at least 15 per cent underweight using the standard scale who were not underweight to this extent when the predictive equation was employed as the criterion.

* Standard Table of Weight for Men as determined by the studies of insurance companies. See reference No. 7.

In other words, 57 per cent of the cases judged in this study to be 15 per cent or more underweight by the "standard" table, (using height alone to predict weight) were not underweight to this extent (usually considerably less) when the factors of hip width, biceps girth, and chest girth are combined and used for prediction of weight. Such a percentage of inaccuracy should be sufficient evidence to justify the use of time necessary to make the three measures for prediction by the devised formula.

In the 459 eighteen-year-old men in this college group, 18 were overweight at least 20 per cent in relation to their "standard" weight, while 5 men were overweight 20 per cent or more when the predictive formula was used. On the latter scale, 15 men would not be 20 per cent or more overweight who would be considered as such on the "standard" table. Three cases were considered 20 per cent or more overweight using the predictive formula who were not classified as such when using the standard scale.

It is quite apparent that a battery of anthropometric traits for prediction of weight is more highly selective than a single variable, such as height. Fewer individuals are considered underweight or overweight when the predictive formula is employed, because constitutional or skeletal type is taken more into account by the use of more anthropometric measurements.

If it can be shown that the use of the predictive formula selects individuals needing more medical attention, and having more defects, than the weight-height tables select, the wider use of the predictive index should be recommended.

PART II

AN ANALYSIS OF FINDINGS FROM THE MEDICAL HISTORIES AND DISPENSARY CARDS OF THOSE MALE STUDENTS DEVIATING 20 PER CENT OR MORE ABOVE OR 15 PER CENT OR MORE BELOW THE STANDARD AND PREDICTIVE WEIGHT NORMS IN THE CLASS OF 1938, UNIVERSITY OF MICHIGAN, DURING 1934-1935

This section of the study will attempt to demonstrate the relation of abnormal and normal findings of health in men to excessive deviation from the standard weight norms* and the predictive weights for eighteen year olds as determined by the predictive formula devised in Part I.

The findings of a study of the histories taken during the entrance examination, the medical data and the ratings of physical educators as reported on the entrance examination records were analyzed. A resume of the various types of illness, causes for dispensary and room calls, reasons for infirmary and hospital admittances during 1934-1935, and the prevalence of these items was made.

Specifically, we are trying to discover if these weight deviation

* *Tables of Standard Weight.* "Based on the records of . . . 221,819 Men accepted by American and Canadian Life Insurance Companies." From *Healthful Living* by Harold S. Diehl, M.D. (New York: McGraw-Hill Book Co., 1935), p. 322.

groups have a greater frequency of specific types of abnormalities than do those whose weights are considered "normal."

PERSONS STUDIED IN PART II OF THE PRESENT STUDY—MALES OF THE CLASS OF 1938, UNIVERSITY OF MICHIGAN

		Number of Men Deviating Excessively From Standard or Predicted Weight											
Age Group	Number Studied	Standard Weight				Predicted Weight							
		20% or More Over		15% or More Under		Total		20% or More Over		15% or More Under		Total	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
17	196	13	6.6	12	6.1	25	12.7	(Predictive Index not determined—insufficient no. of cases)					
18	459	18	3.9	23	5.0	41	8.9	5	1.1	5	1.1	10	2.2
19	221	12	5.4	14	6.3	26	11.7	(Predictive Index not determined—insufficient no. of cases)					
Total	876	43	4.9	49	5.5	92	10.5	5	.57	5	.57	10	1.1

The predictive formula indicated five men deviating from the "normal" who did not deviate from the "normal" in respect to the Standard Table. In other words, when variables other than the single one of height in relation to weight were used, only ten cases were considered to be excessively under- or overweight. The predictive formula takes into consideration the skeletal build or type of the individual by considering chest circumference, biceps girth, and hip width. The standard tables are lacking in this regard as they use only one anthropometric variable to predict weight, that is, height. With the use of the Standard Tables, 10.5 per cent of the 876 cases deviate from the arbitrary standards (15 per cent or more underweight; 20 per cent or more overweight) which have been chosen. With the use of the predictive weight formula for the eighteen year olds, 2.2 per cent are selected as under- or overweight, while with the use of the Standard Tables 8.9 per cent are chosen. If the predictive formula is valid, then we have a more selective screen than the usual height-weight tables for determining deviation from weight.

Not all of the items on the history blank were considered in this study. Those factors included were presumed to have some relation to over- or underweight; others were chosen for study merely from the standpoint of personal interest.

Family health, parents' build, the student's past and present health, his habits, his opinion of his own health, his nutrition, the health ratings given by medical examiners, dispensary and room calls made during the school year 1934-35, hospital and infirmary days during the above period, and diagnosis of disease were all studied. The items on the following table were the only ones found to possess significant

differences in occurrence in the weight deviation group when compared with the entire freshman class of men.

ITEMS ON HEALTH RECORDS SHOWING SIGNIFICANT DIFFERENCES

Item	Standard Weight Deviation Group (N—92)		Entire Class (N—1167)		Actual Difference between the Two Observed Percentages	Standard Error of Proportion	Standard Units
	No.	%	No.	%			
General Health Appearance (Medical) Rating							
Good	73	79.0	1034	88.0	9.0	.03	3.0
Nutrition (Medical) Rating							
Good	37	40.0	954	81.0	41.0	.06	6.8
Health (Medical) Rating "B"							
"B"	65	70.0	615	53.0	27.0	.06	4.5

PART III

GENERAL CONCLUSIONS AND RECOMMENDATIONS

1. From the review of the literature on the use of anthropometric measurements in the prediction of weight, one finds that height alone is no longer considered a valid index of weight. Although many investigators have reported higher correlations between weight and chest girth expanded than between height and weight, none of them has recommended this combination of anthropometric measurements to replace the height-weight index.

Most investigators in studying the relation between constitutional types and incidence or proneness to specific illnesses are surprisingly in agreement as to a definite relationship between certain bodily types and specific illnesses. However, there is still much to be done in verifying these relationships.

2. The following formula for predicting weight in eighteen year old college males has been devised in this study:

Predicted Weight = $1.203 \times \text{Chest Girth Expanded (in inches)}$
 $+ 1.168 \times \text{Biceps Girth Contracted (in inches)} + 2.654 \times \text{Hip Width (in centimeters)} - 19.006.$

Predicted weight from this formula has a much higher correlation with actual weight than does height alone. The significance of this predictive weight in relation to the health or nutritional status of the individual remains to be determined in some future study. Due to the lack of

cases in age groups other than the eighteen year olds, a predictive formula for the latter group alone could be determined. When the predicted weight for each of the 459 eighteen year old freshmen was determined, only 5 students deviated 20 per cent or more above their predicted weight, and only 5 students deviated 15 per cent or more below their predicted weight. These 10 cases are obviously inadequate to determine the significance of this predictive index in relation to health status. Nevertheless, the writer believes that it may have significance in this respect since the only death occurring in males of the class of 1938 during the year 1934-1935 was among these ten boys. Further, the only boy in the class of 1938 who had to leave school on account of illness during 1934-35 was also one of this group deviating widely from his predicted weight. Another member of this group did not return for the school year, 1935-36. These specific cases may all be coincidences. Nevertheless, they indicate (to the writer, at least) that a future study involving a statistically adequate number of cases deviating from their predicted weight would be justified, and might even prove that this index has considerable significance in relation to health status.

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